Journal of Constructional Steel Research 73 (2012) 117–127

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Shape effect on the behaviour of axially loaded concrete filled steel tubular stub columns at elevated temperature

X.H. Dai, D. Lam *

School of Engineering Design and Technology, University of Bradford, UK

ARTICLE INFO

Article history:
Received 7 October 2011
Accepted 3 February 2012
Available online 29 February 2012

Keywords:
Concrete filled steel tube column
Hollow section shape
Heat transfer
Critical temperature
Fire exposure time
Numerical modelling

ABSTRACT

Concrete filled steel tubular columns have been extensively used in modern construction owing to that they utilise the most favourable properties of both constituent materials. It has been recognized that concrete filled tubular columns provide excellent structural properties such as high load bearing capacity, ductility, large energy-absorption capacity and good structural fire behaviour. This paper presents the structural fire behaviour of a series of concrete filled steel tubular stub columns with four typical column sectional shapes in standard fire. The selected concrete filled steel tube stub columns are divided into three groups by equal section strength at ambient temperature, equal steel cross sectional areas and equal concrete core cross sectional areas. The temperature distribution, critical temperature and fire exposing time etc. of selected composite columns are extracted by numerical simulations using commercial FE package ABAQUS. Based on the analysis and comparison of typical parameters, the effect of column sectional shapes on member temperature distribution and structural fire behaviour are discussed. It shows concrete steel tubular column with circular section possesses the best structural fire behaviour, followed by columns with elliptical, square and rectangular sections. Based on this research study, a simplified equation for the design of concrete filled columns at elevated temperature is proposed.

1. Introduction

Steel is a highly thermal conductive material, however it loses its strength and stiffness quickly when exposed to fire. Therefore, it is vitally important to consider the structural fire behaviour of steel and steel composite members to ensure that they have the appropriate fire resistance. Bailey [1] highlighted the advantages and disadvantages of the fire design methods currently available for steel structures. For steel tubular column members, diverse fire protection methods may be adopted to promote the fire resistance ability. Applying intumescent coating to the steel surface is an effective approach, however it is expensive and intumescent coating itself does not provide any structural strengthening to the structural elements. Being a thermal inertial material, infill concrete has been recognized to provide an effective temperature sink that lowers the temperature in steel during fire. Furthermore, the temperature of concrete core rises much slower than that of steel tube thus the concrete core may provide appropriate load capacity even when the steel tube reaches a high temperature.

Research focused on the structural fire behaviour of typical concrete filled columns under conventional loads has been extensively carried out. Kodur et al. [2,3] investigated the load carrying capacity and fire endurance period of concentrically loaded hollow structural section columns filled with plain concrete, bar-reinforced concrete and steel fibre-reinforced concrete and their work indicated: in the practical range for building construction, appropriate fire resistance can be obtained for hollow structural section columns through concrete filling. Wang [4] studied the effect of structural continuity on the fire resistance of concrete filled steel tubes. The research validated the recommendation of build-in boundary conditions for continuous columns given in BS EN 1994-1-2 [5] and suggested that in the fire limit state, the additional axial loads induced by thermal expansion were very small and the bending moments generated are much lower than those applied at the ambient temperature. A state of art report [6] illustrated the current state of research and basic design principles of steel–concrete composite structures in fire, it also addressed the design of composite columns and performance of concrete-filled tubular columns in fire.

To further understand the structural fire behaviour of concrete filled steel tubular (CFST) columns, researches carried out were not only on monotonic axial compressive behaviour, but also on other important aspects which including post-fire behaviour, dynamic performance and developments of experimental procedures and numerical methods etc. Tao et al. [7] tested a series of concrete filled steel tubular stub columns and the test results indicated that fire exposure had a significant effect on the bond between the steel tube and its concrete core. A decrease in bond strength was generally observed for specimens after a fire exposure of 90 min, but bond strength recovery was observed when the fire exposure time was extended to 180 min. Experiments performed by Han et al. [8,9] on the cyclic behaviour of concrete filled steel tubular columns found that concrete filled hollow

* Corresponding author. Tel.: +44 1274234052; fax: +44 1274234525.
E-mail address: d.lam1@bradford.ac.uk (D. Lam).

0143-974X/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcsr.2012.02.002